Application of Radar Remote Sensing in Mapping and Monitoring Tropical Forest Types in Amazon Basin

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Abstract

The Amazon basin has the largest continuous region of tropical forest in the world. There has been an increasing interest in the fate of this region as its diversity of species and forest types have been threatened by widespread land-use change and deforestation in the past two decades. There is a general agreement that as the mature tropical forest converts to other land covers, a major part of the terrestrial carbon will be released to the atmosphere through burning, removal of biomass, and decomposition of soil and organic matter. The ambiguity in estimating the terrestrial carbon flux is primarily due to uncertainties in the spatial extent of the various types of primary forest, forest regeneration, and the rate of deforestation. Therefore, mapping and monitoring the Amazon basin have become a priority for several scientific disciplines. In this study, we explore the role of radar remote sensing in mapping forest types in the Amazon basin and estimating and monitoring deforestation. We will make use of a combination of radar sensors such as JPL polarimetric AIRSAR system operating at P-, L-, and C-bands, SIR-C/X-SAR L- and C-band polarimetric system, and JERS- 1 L-band HH polarization imagery. The data will be used to understand the capability of SAR imagery in separating and classifying major forest types in the Amazon basin such as lowland moist forest, upper and lower rnontane moist forest, inundated forest (permanent swamp forest, varzea and igapo forests), gallery forest, dry woodlands and savanna, and transitional forests (dominated by bamboo, lianas or palms). Furthermore, the sensitivity of SAR frequency and polarization to forest biomass and structure arc examined in order tocharacterize several clearing practices and forest regeneration within the region. The results indicate that: 1) L-band and P-band HV polarizations show strong sensitivity to secondary biomass regrowth in the early stages of regeneration, 2) HH polarization at these frequencies are suitable for mapping and monitoring the seasonal changes in flooded forests and mangroves, 3) application of C-band channels are limited to non-forested areas. C-band HH polarization can be used to map mangroves in coastal regions. Due to signal saturation, however, it cannot separate the inundated forests throughout the basin accurately. The best channel for large scale mapping and monitoring forest inundation is L-HH, and 4) a combination of SAR backscatter and texture information can be used in classifying dry woodlands and savanna, gallery forests. The examples are given from three experiments over the Amazon basin in Peru and Brazil and the results arc verified by using maps and field data collected during the experiments.

This work has been performed at the Jet I'repulsion Laboratory, California Institute of Technology under a grant from the National Aeronautics and Space Administration.

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ARTIFICIAL NEURAL NETWORK DERIVED PLANT GROWTH MODELS *

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The goal of the Advanced Life Support Systems (ALSS) is to provide self-sufficiency in life support for productive research and exploration in space, for benefits on Earth and to provide a basis for planetary explorations. Part of this objective is to be able to grow crop plants in one or more controlled environments for the purpose of providing life essentials to a human crew, such as oxygen, potable water, and food. To do this reliably and efficiently, it is necessary to achieve control of the rates of various plant physiology processes. including: net exchange of exhaled carbon dioxide for oxygen (net photosynthesis), purification of water (transpiration), and food production (biomass production rate and harvest index).

To develop an efficient control system that will be able to manage, control, and optimize plant-based life support functions, system identification and modeling of plant growth behavior must first be done. We have developed a plant growth (physiology) model using artificial neural networks. Neural networks are very suitable for both steady-state and dynamic modeling and identification tasks, since they can be trained to approximate arbitrary nonlinear input-output mappings from a collection of input and output examples. In addition, they can be expanded to incorporate a large number of inputs and outputs as required, which makes it simple to model multivariable systems. Thus, unknown nonlinear functions in dynamical models and controllers can easily be parametrized by means of multilayer neural network architectures.

Artificial neural networks are composed of simple albeit numerous non-linear processing elements (modeled after biological neurons) interconnected through a complex network of variable strength connections (modeled after biological synapses). The topology of interconnections and the synaptic strengths essentially dictate the functionality of a given network. A typical network is capable of receiving a large number of analog/digital inputs (e.g., sensor signals) in parallel, and after a complex nonlinear transformation operation, provides the outputs (e.g., predicted growth, biomass). The unique strength of such neural network architectures emerges from their ability to build up their own rules through learning from examples the underlying input/output transformations in ill-defined problems.

In this paper, wc will describe our approach to developing these models, the neural network architecture, and the results. With the usc of neural networks, these complex, nonlinear, dynamic, multimodal, multivariable plant growth models will be able to better interpolate between all the various environmental conditions and parameters and be able to simulate both short-term (day-to-day) and long-term (plant life cycle) growth of various plants.

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